

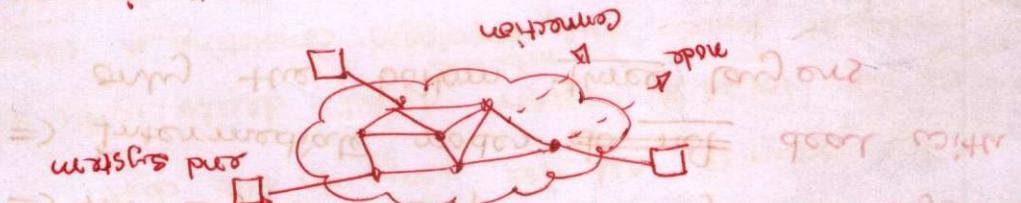
- A network that provides many services needs many protocols. Some services are independent, but others depend on each other. Even a protocol may use another protocol in its execution.
- The form of dependency in a set of protocols is managed by layering. Here, each layer implements a service by layering. Thus, if soon internal-layer action and by relying on services provided by the layers below.
- All these interactions & relationships of complex systems are of the form of layers of abstraction. → Alternative of layering:

 - All uses distinction & relationships of complex systems pieces
 - Zeros maintenance and updating the system
 - Example scenario: classical mailing system

Protocol is necessary for many functions that require

comes and formats : Protocol

Community action over a motorcar is governed by a set of rules.



* Computer Network: A collection of nodes and connection

Jones f. Kneer, Keith W. Ross

William + strawings

② Data and computer communications (data processing)

Larry L. Peterson, Bruce S. Davis

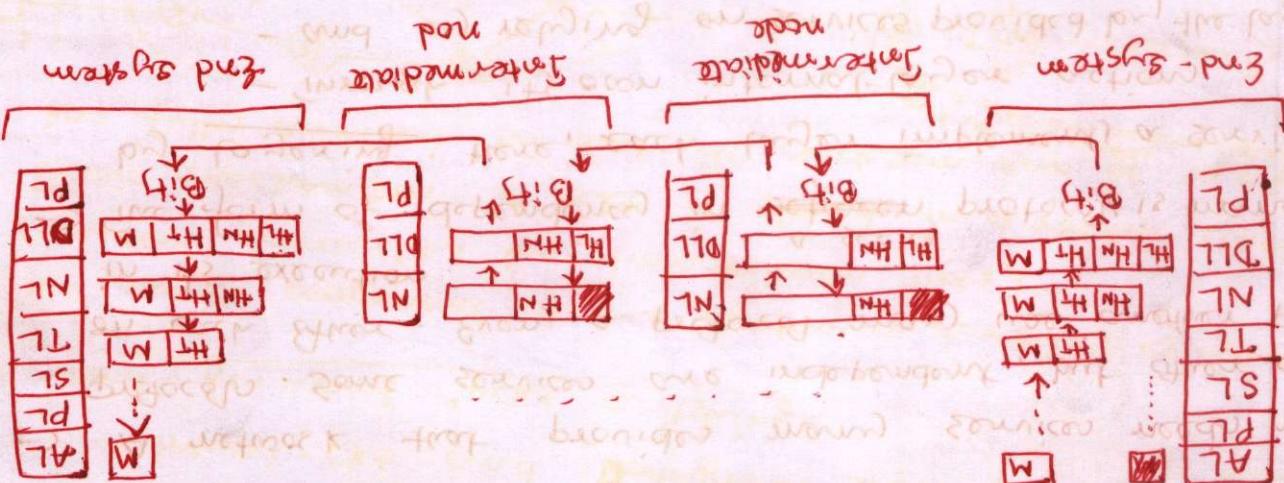
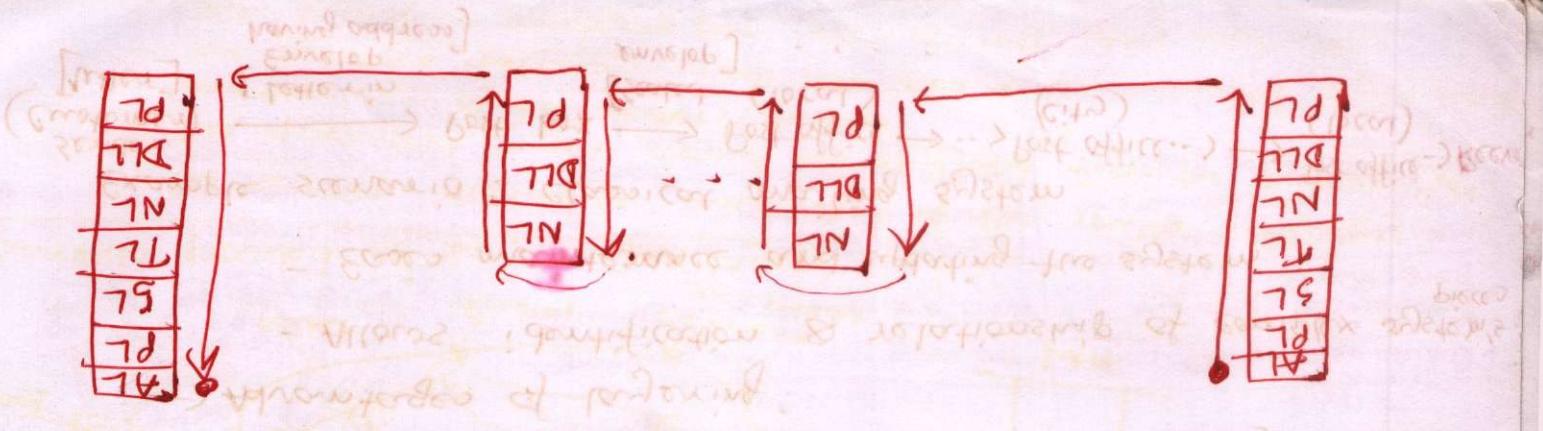
① Computer Networks: A Systems Approach (4th edn)

- Grandes cataratas, Iguazú,瀑布

Computer Networks (4th edition) - <http://www.cs.tut.fi/~jkorpela/network/>

Conqueror of the world (the whole earth)

Ex 32: Computer Networks



Point transmission using OSI reference model

=> Physical layer: transformation of information into electrical signals

only the bottom three layers

=> Intermediate mode ~~is~~ deal with

=> All layers are part of the end system

Physical	Physical
Data Link	Data Link
Network	Network
Transport	Transport
Session	Session
Presentation	Presentation
Application	Application

Layers in OSI
adopted as a reference model for computer network

- Open System Interconnection (OSI): widely

a standard to connect open systems

International Organization for Standardization (ISO) protocols

A system that implements open protocols is called open system

- members of public and transmission are open to the public

- changes are managed by an organization whose

- protocol details are publicly available

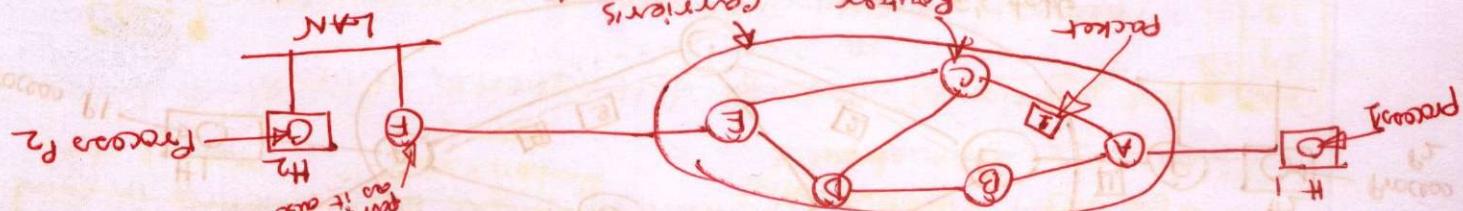
A set of protocols is open if

Open protocols and systems

use a uniform numbering plan; even across LANs and WANs.

- The network layer should be shielded from the numbering
- The services should be independent of the router technology

services provided to the transport layer



host fully arrived so that its checksum can be verified

- Basic mechanism: A packet is stored in a router until it

(routers connected by transmission lines)

- The major component of the system is carriers equipment

Store-and-forward packet switching

Virtual circuits

connectionless and connection-oriented service

store-and-forward packet switching

Decide on routes to each destination

know the topology to forward to the appropriate port

Router issues for the network layer

choose appropriate ports through it

What knows the network consisting a set of routers (called subnet)

Two lowest layer that deals with end-to-end transmission

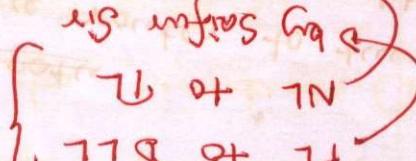
the source all the way to the destination

Network layer is concerned with getting packets from lower layers [back by routers]

store-and-forward approach

very simple functionally

Chapter 5: Network Layer



User approach: Hybrid of them!

(AL to PL)

top down approach; Kurose

(PL to AL)

bottom up approach; Lambrini

Approach of studying computer networks

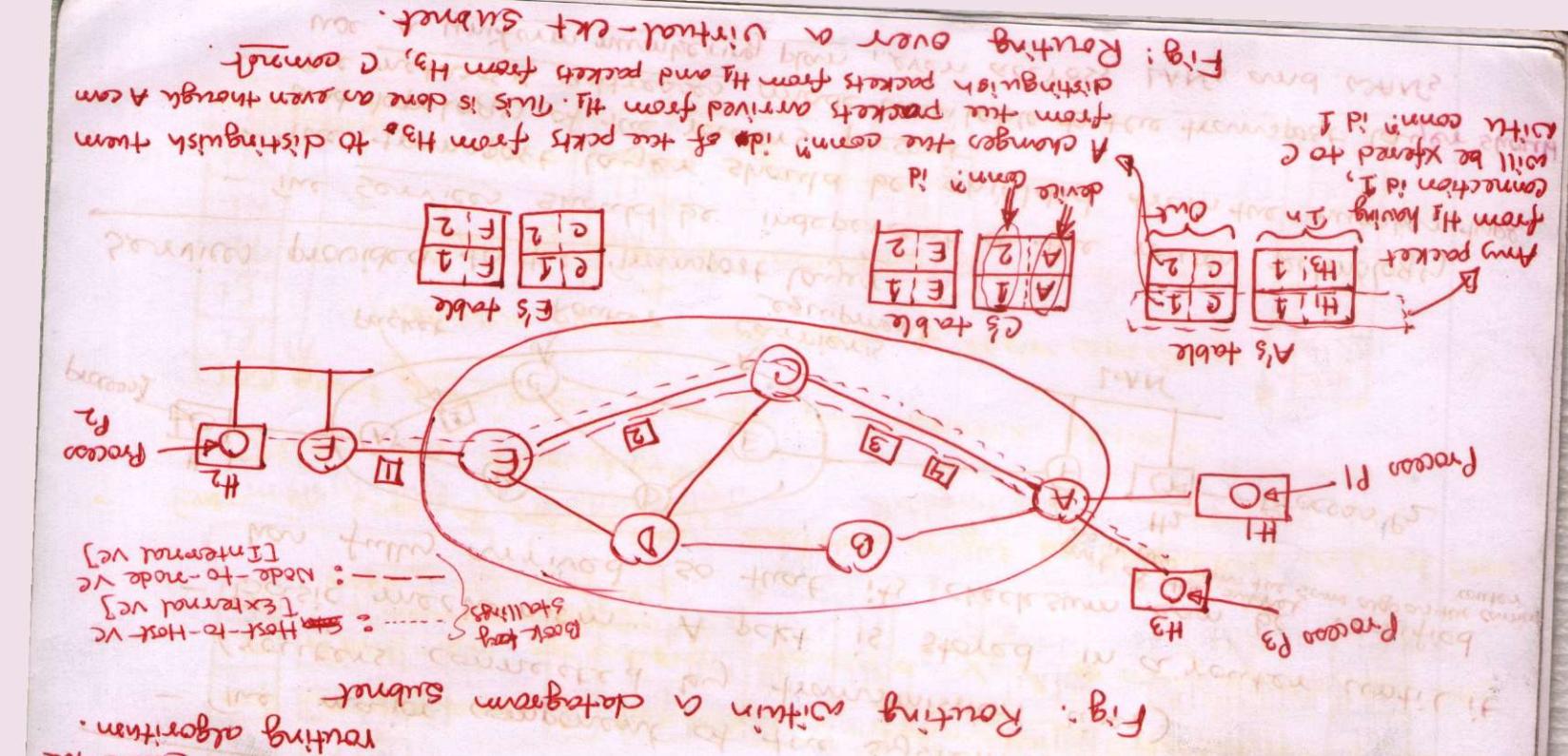
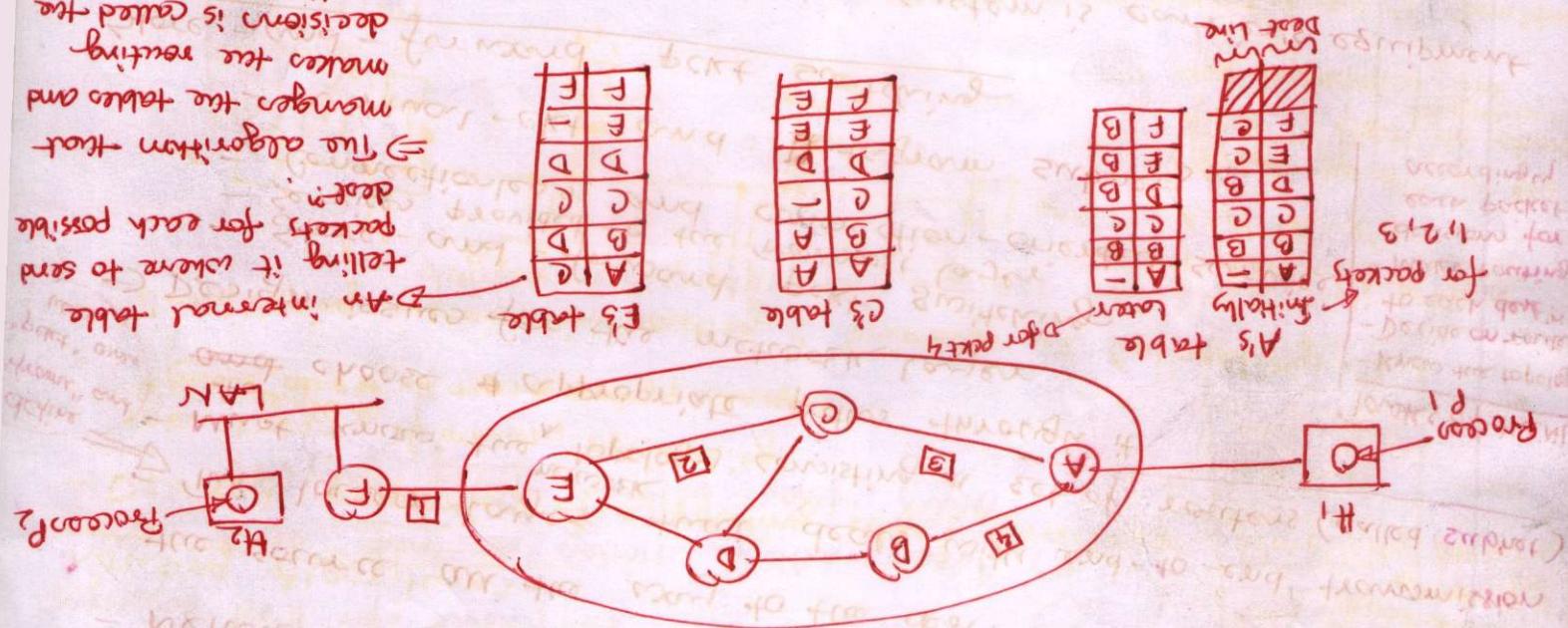


Fig: Routing within a datagram subnet.

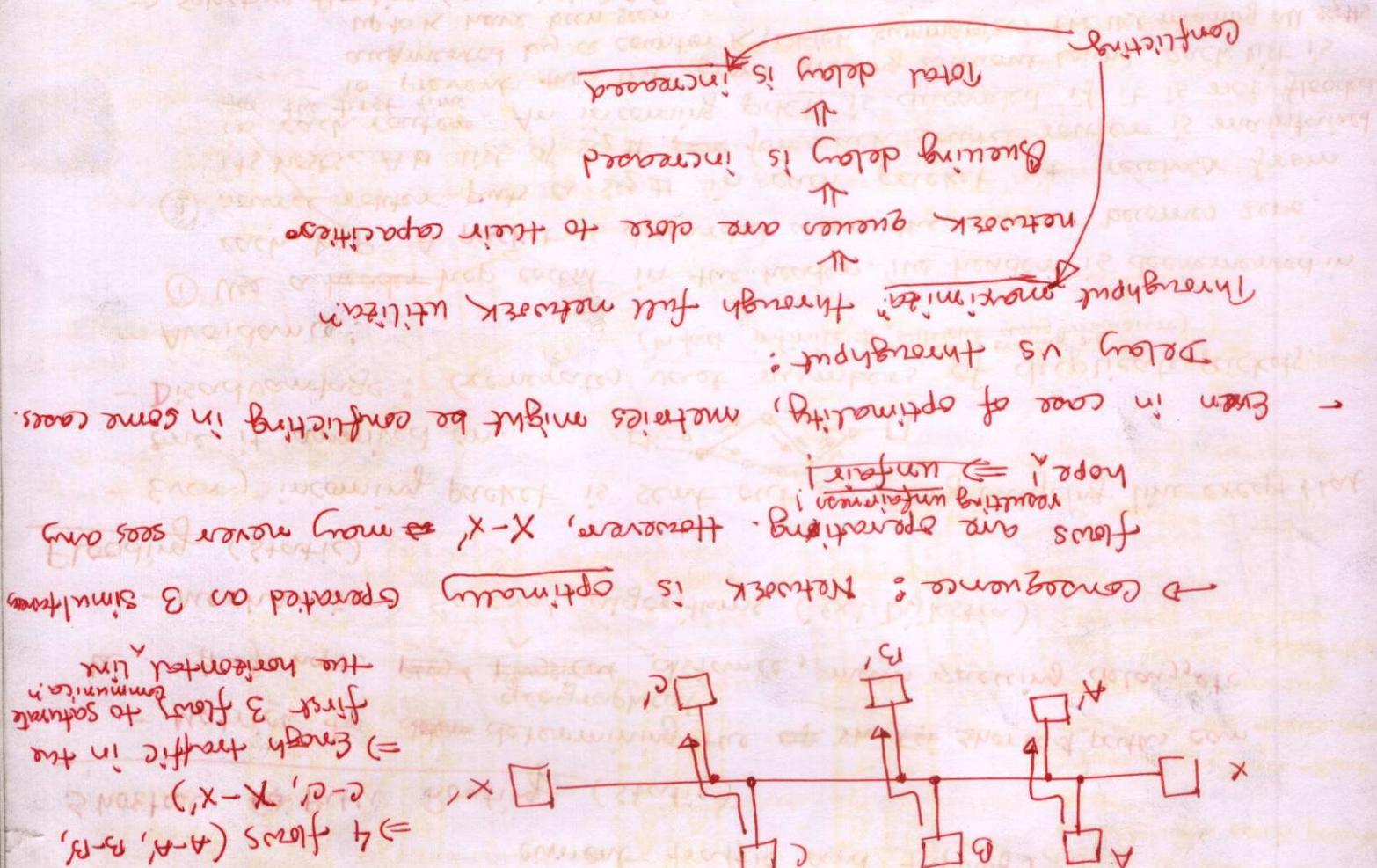


② Connection-oriented service: ~~Point~~ ~~from point of view~~

- packets are terminated on ~~the~~ datagram subnet
- the connection is a virtual-cut subnet

① Connection less service:

- packets are injected into the subnet individually and routed independently of each other.
- the connection less service is a virtual-cut subnet



- Congesting metrics in routing: fairness vs optimality

robustness to failures, optimality

- Desired properties of a routing algo: correctness, simplicity, stability

Issue	Virtual-rek subnet	Virtual-rek subnet	No	Central info	in each packet	Routing dr each packet	Routing dr each packet	Bus	max. latency	Convergence	Centralization
Setup fee?											
Get setup fee?											
Virtual-rek subnet											
Target subnet											
Get setup fee?											
Central info											
Full src and dest. addresses											
A short ve number											
Follows the route chosen after											
source ve starts											
None, only the packets transmitted											
all VEs that passed through + the failed router are terminated + the driver to the mesh will be lost											
if enough resources available, if each VC in advance allocated for each VC in advance											
↳ should work outwards											
↳ should converge											
↳ should be proportional to the length of the path											

Getting approximate delay in the right direction.
 ⇒ Selective flooding (a variation): Incoming packets are sent only on those links that are up to K hops away from the source.

Augmented by a counter K , which summarizes the last message all nodes have seen. To prevent the last from growing without bound, each life is limited for each router. An incoming packet is discarded if it is seen before its header is received.

Source header puts a seq# in each packet if it receives from each hop. A packet is discarded when the counter becomes zero.

① Use a ~~header~~ hop count in the header. The header is decremented in each hop.

- Advantage: (In fact, it finds the shortest route to the destination)

- Disadvantage: generates waste numbers of duplicate packets.



- Every incoming packet is sent out on every outgoing link except that

Flooding (static)

- Mechanism: Source algorithm (ex: Dijkstra)

- Metrics for determining the shortest path can be: # of hops, geographic distance, mean queuing delay, etc.

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Shortest Path Routing (static)

- Current traffic and topology

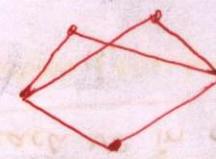
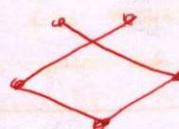
- Decision on measurements of alternatives of the

- Static/Non-adaptive: Every node uses their fixed routing

- in current traffic & topology

- Adaptive: Dynamic routing decision based on metrics

Routing algorithms



→ A set of optimal routes from all sources ~~to~~ to a given destination form a tree rooted at the destination: Sink tree

then the optimal path from J to K also falls along the same path

⇒ If router J is on the optimal path from I to K to L then the optimal path from J to K implies $J \rightarrow I \rightarrow K$ to be optimal.

Conversely

Optimality principle:

Conflicting: ex: # of hops ↑ (delay ↑ BW constraint ↑) (throughput ↓)

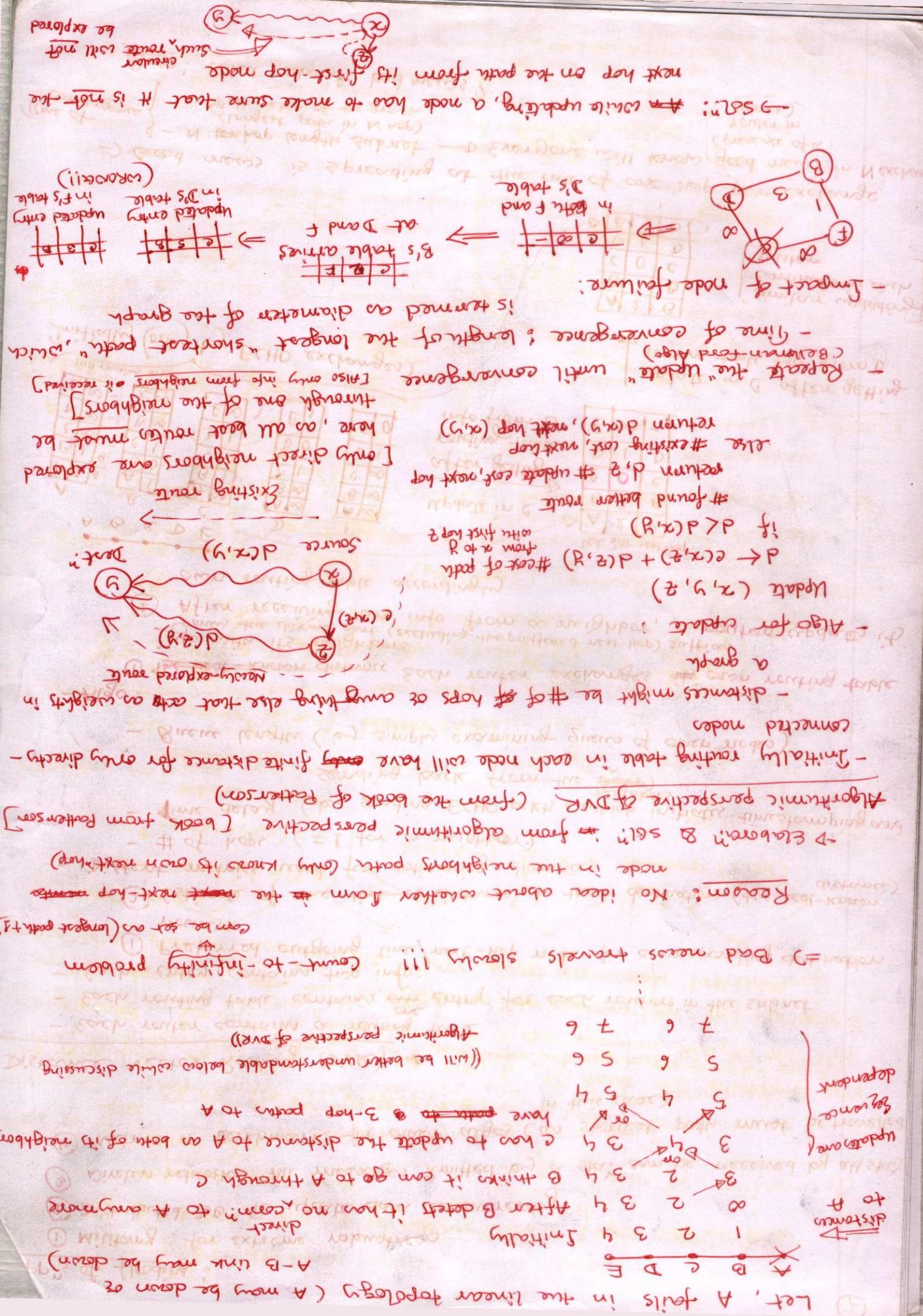
However, in some cases delay and throughput might not be

- Distance Vector Routing (DVR) *

 - Each router contains a routing table
 - Each routing table contains one entry for each router in the subnet
 - Each entry contains two info:
 - Each entry contains one entry for each router for corresponding destination
 - ① Preferred outgoing link/next-hop node for each router
 - ② Estimate of the time distance to that destination (the best-known distance)
 - Different metrics used for estimating distance
 - # of hops (= I for a neighbor)
 - Time delay (by sending ECHO packets, which includes timestamping and sending back from the next-hop)
 - Round trip (by simply examining queue of other nodes)
 - Router length -
 - After receiving info from a neighbor, a router updates its routing table by the distance part (excluding the preferred next-hop) suffixed with its own info
 - ② After receiving info from a neighbor, a router updates its routing table by the distance part (excluding the preferred next-hop) suffixed with its own info

* Distance vector routing (DVR)

- ① Multistage: for extreme robustness
 - ② Distributed DB: To update data simultaneously
 - ③ Divergent replication; all messages committed by a step can be received by all steps
 - ④ Message of Bonchmark for other algs (in shortest path must be traversed)
in this case



~~Ques 4~~ ~~Ques 5~~ ~~Ques 6~~

traffic changing \Rightarrow only one link splits in multiple lines in fraction

\Rightarrow LAN: traffic is split over multiple lines in fraction

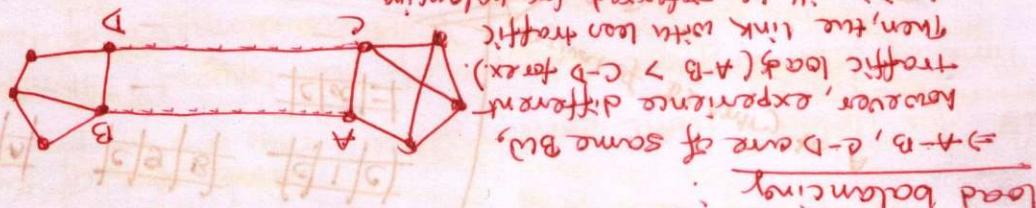
traffic change in traffic load over a link just after one update

\Rightarrow Problem of considering LB: oscillation in traffic load

$(A-B > C-D) \leftrightarrow (C-D > A-B)$

$(A-B > C-D) \leftrightarrow (C-D > A-B)$

\Rightarrow Problem of considering LB: oscillation in traffic load



② When the echo packet arrives in front of A: does NOT consider load balancing

① When the echo packet is queued: considers load balancing

\Rightarrow Two different techniques for starting the RTT timer.

② Measuring Line Cost? The echo packet is sent immediately. ($\text{delay} = \frac{RTT}{2}$)

\Rightarrow Measurement of delay/cost to neighbors through exchanging special echo packets

① Discover neighbors? Idenitification of neighbors through exchanging special HELLO packets

① Discover neighbors? Compute shortest path to neighbors \Rightarrow Send info to all others \Rightarrow Every other router receives the cost to neighbors

Discover neighbors \Rightarrow Measure cost to each neighbor \Rightarrow construct a packet incorporating

\Rightarrow Five operational steps in LSR: (B.1) quadtree, (B.2) neighbor, (B.3) discovery

LSR: sends info of neighbors to all nodes

DUR: sends info of all nodes to neighbors

\Rightarrow Basic difference with DUR:

(B.4) quadtree

(B.5) discovery

→ \Rightarrow (B.1) quadtree: secondly it is reduced. Moreover, the resources still depends on the number of dependents

② make initially similar first # (ex: 100)

① Propagate bad news feature: triggered update for receiving

\Rightarrow After SPAR: ensure better sequence in update

\Rightarrow Problem: lot more info needs to be exchanged

\Rightarrow Possible step: track down and distribute the entire path

Multi-hop eucular route!

A adopts the path $D \rightarrow B \rightarrow A \rightarrow \dots$ in which it sees an intermediate node

entire path is NOT known

\Rightarrow Reason behind geometric-dependent convergence: Only neighbor is known,

Metrics: Netwrok throughput, end-to-end delay, jitter, etc.

MAC at NL at GL (for own PL models) \Rightarrow change any of them with some intuitive explanations

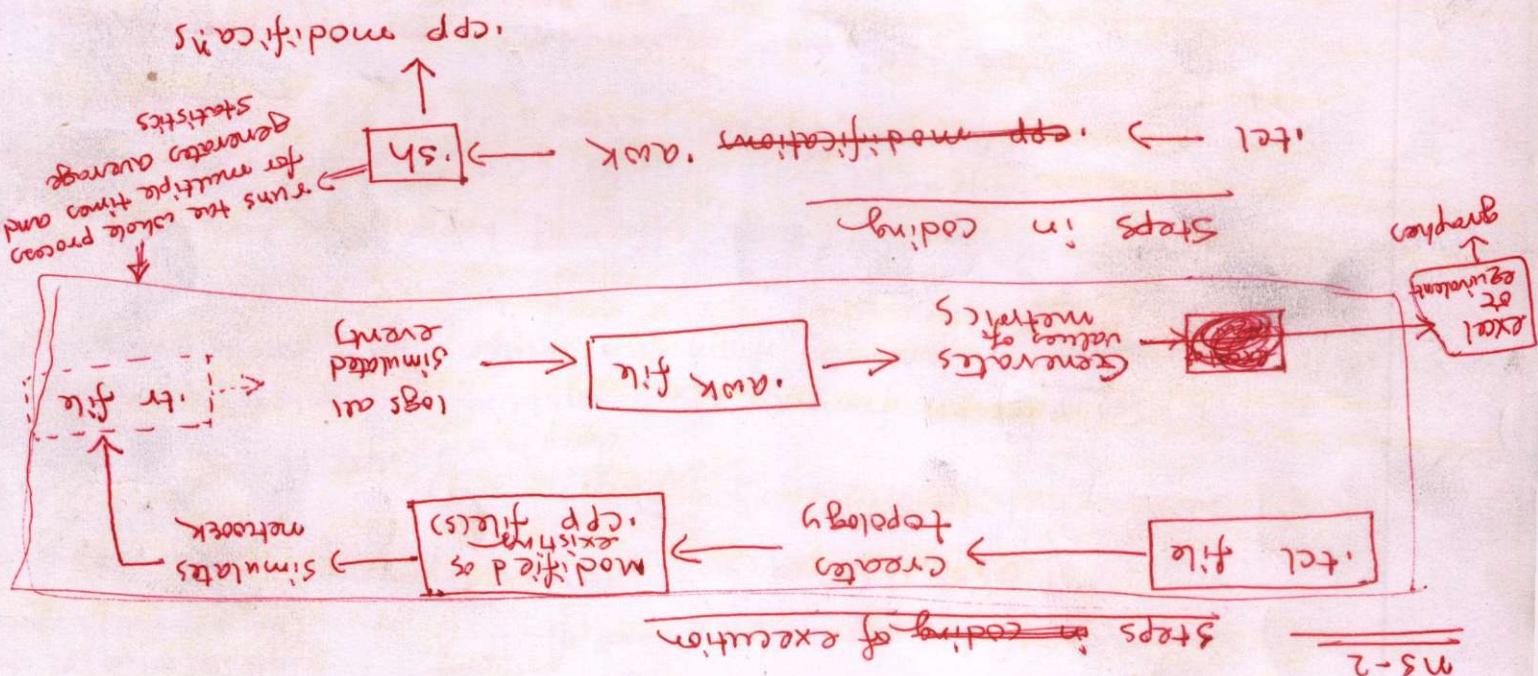
write averaged value to a file
and loop

extract averaged value of the generated metrics
run awk and generate metric values for the simulation run

change after loop start

define network attr \rightarrow var # of nodes, data rate (bps, payload size, etc.)

MS



mobile ad-hoc network, vehicular ad-hoc network, ...

Different names \Rightarrow different total # of hierarchical topologies, ad-hoc networks, mesh networks, ...
(only exception: Satellite)

\Rightarrow combination of at least two types as mentioned above

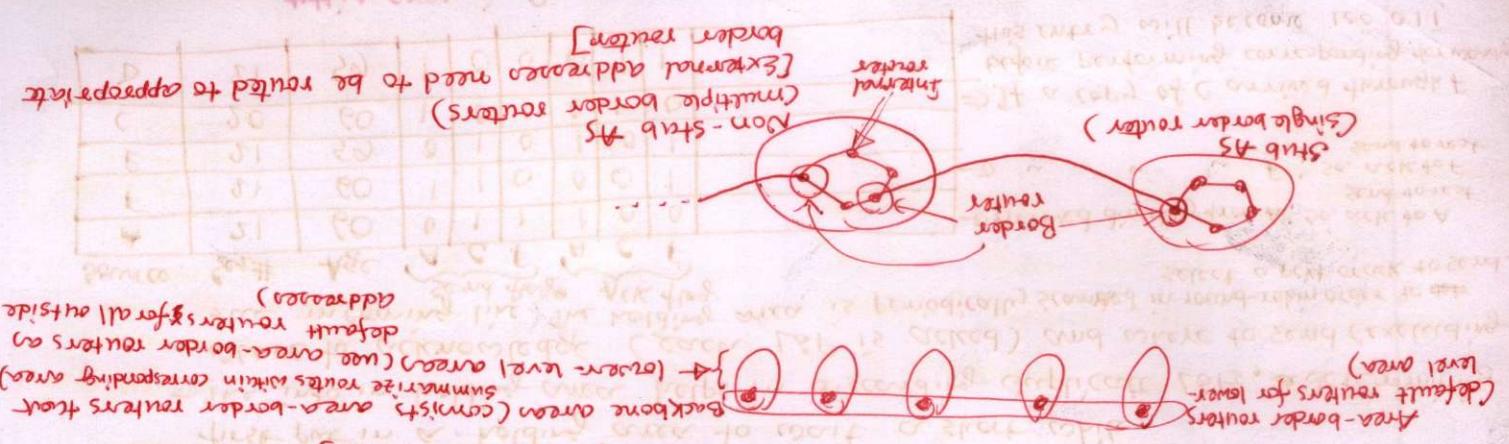
Wireless, a. UWB, Mobile, Sensor, Satellite

Different types of networks

- Simulation of different types of networks in MS-2 with already available as modified protocol and produce different values of different metrics

after 10 classes

Project:



In such environments, systems (ITIS) are taken as services (large and non-trivial to manage). Therefore, they can be organized in hierarchy.

Autonomic nervous systems (ANS) are from the central nervous system under a single administrative control.

\Rightarrow OSPF resulting hierarchy;

Q2) Types of Service (TOS) metrics: Link characteristics varries in multiple dimensions
such as latency, throughput, cost, reliability
→ Example: Satellite link provides high throughput long latency link, whereas
fiber optic link provides lower throughput low latency link, whereas

$\Rightarrow \log\#$, age, load balancing \hookrightarrow Similar to discussed above

- Router sets the seq # to $\max(\# + 1)$ and re-sends

- \$2 # set to 0 ; Router will send LSAs .

③ What happens when Router goes down & back up?

What effect does it have if you trigger and (when elements happen) Periodically? i.e. performed?

000-126^o Schencky from 400' ~~1000 ft~~ = back up 200' over a

< : send back to sender following notification

< Update & propagate to all other lines

↳ Please refer to LSA Clinical study Adverse Events

- 85 - *(Open standards; SPC. Another name of QMS standards and so on)*

examples of LSRs: O3Fe (open shell octet FeII), FeS - FeS (inner shell d¹⁰ outer shell t_{2g} 5p back bonding).

Example of use: open source tool like GIMP - it's a free system - it's

Disturbance
Complexity

Complex	Simple	Complex
Complex as source of bugs	No (using single path)	Complex multiple paths

Electric car	Wear & tear	No. (Only single path)	Proprietary multiple paths
Sophisticated	Cost four times	Yes	Proprietary multiple paths

Foot ~~metabolic~~ ~~metabolic~~ ~~metabolic~~ ~~metabolic~~ ~~metabolic~~

attribute Attribute LSR DUR

transporter between DVR and LSR

→ (swayBrow to # * eyeDilate to # ~~20~~) remains for geometry ←

Computational fluid dynamics solve large systems

Probability distribution of age

காலத்திலே குறிப்பிட்டுள்ள வருடங்களில் முன்னால் நிறைவேற்றுவது அதே நிலையிலே செய்யப்படும்.

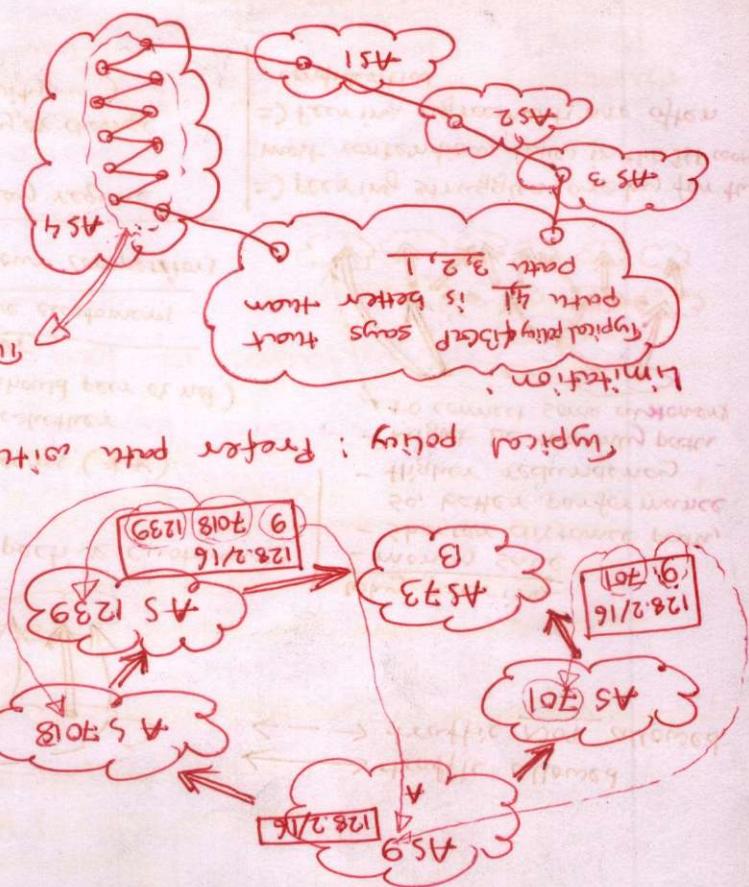
- shortest path detection in each node using Dijkstra's

middle it's represented twice, which can be used separately or all at once.

- (envelope) entire subplot groups after accumulation all LSPs.

Computer shorter posts of every day's news should be 0-100 words.

- Scalability: AS forwards packet to any address in Internet
 - Domains are autonomous: No idea about interior protocol/metrics used within each domain
 - Downwarded by policy, domain consideration: In AS many not carry traffic between other ASes
 - Goal of BGP: A lot of AS many not carry traffic between two other ASes
 - Simplify finds a path between two nodes
 - Does NOT try to "optimize" path
 - Path vector algorithm with extra information
 - Extra info: for each route, store the complete path (AS)
 - No extra computation, just extra storage
 - Can make policy based on set of ASs in path
 - Can easily avoid loops
 - Can easily avoid loops



\Rightarrow Key considerations in BGP:

- An example of inter-domain routing: Border Gateway Protocol (BGP) [Paterson's book]
- What about this??
 - Inter-domain routing
 - Large ISP
 - Small ISP
 - ISP
 - ISP
 - Private Network
 - Ex: Internet - II
 - 16 bits
 - ASNs (AS Numbers)

